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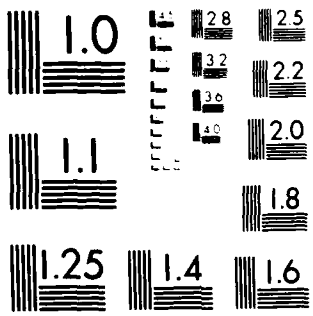

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THESIS

The Impact of Reliability Improvement Warranties
on Naval Aviation Maintenance
at the Fleet Level

by

Donald J. Shutt
and
James H. Martin

December 1982

Thesis Advisors: J. W. Creighton
J. R. Bergquist

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The Impact of Reliability Improvement Warranties on Naval Aviation Maintenance at the Fleet Level

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ABSTRACT

The recently published DoD Acquisition Improvement Program increases the emphasis placed on using Reliability Improvement Warranties as a means to improve weapon system reliability and maintainability. Several previous studies have concentrated on RIW selection criteria, cost factors, and reliability improvement incentives. The authors believe that adequate attention has not been given to the fleet level impact of utilizing RIWs. This study reviews past and present contracts to assess these RIW impacts on the Naval Aviation community from an operational and supply point of view. The complexities of fleet level management of warranted assets, the risks posed to the contracting parties, the opinions of fleet maintenance managers, and the RIW's expected fiscal benefits, are among the items discussed.

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I. INTRODUCTION

A. GENERAL

The need for improved aviation weapons system reliability and maintainability is of significant concern within the Department of Defense (DOD). Increasing cost and complexity of weapon systems coupled with tougher interservice competition for the defense dollar dictates a need to explore alternative methods of ownership cost reduction. Recently, the acquisition process has emphasized ownership cost reduction by focusing on Operations and Support (O & S) as well as acquisition costs. One avenue receiving increased attention is improved weapon system reliability.

Sparked by significant reliability problems, an intensive improvement program commenced in the early 1970's. Since that time the reliability and maintainability question has received considerably more attention. Operational reliability is now a major concern of the Defense Systems Acquisition Review Council, an essential factor in the design concept, and most recently highly emphasized in the DOD Acquisition Improvement Program, i.e., actions 9 and 16 of the proposed initiatives [Ref. 1].

The Reliability Improvement Warranty (RIW) concept is one attempt to obtain equipment with increased reliability and maintainability and to reduce the cost of maintaining equipment. The recently published DOD Acquisition Improvement Program increases the emphasis placed on using RIWs as a means to improve the reliability and maintainability of complex and expensive weapon systems [Ref. 2]. Despite this emphasis the acceptance of RIW has not been universal and many elements doubt the actual value and success of the concept.

B. PROBLEM STATEMENT

Reliability Improvement Warranties were created as a tool for lowering life cycle costs through reduced maintenance. The RIW concept appears to be in consonance with the Department of Defense's need to improve combat effectiveness while reducing weapon system support costs. Each year the acquisition, manning and maintenance of a modern defense force has become increasingly complex and expensive. This complexity of new weapons systems is surpassing budget constraints and straining the ability of the military to maintain the systems.

RIW contracts are recent, but not entirely new to the military, and some contracts have drawn to a close. It is imperative that past and current RIW contracts be comprehensively evaluated for their cost and mission effectiveness to determine whether systems merit future RIW contracts because of proven, and not theoretical, success of the RIW concept.

C. SIGNIFICANCE OF PROBLEM

One of the principal concerns of the Chief of Naval Operations is the poor state of fleet readiness. A major contributor to this condition has been the relatively low reliability of systems and components and the inherent difficulty in maintaining them at sea. These support deficiencies can be overcome and avoided if recognized and addressed by management in the early stages of the acquisition process. The acquisition strategy must provide for reliability and maintainability engineering support as an integral part of system design.

As recognized by the Naval Material Command [Ref. 3], reliability and maintainabilty (R & M) must be highly placed in the minds of people at all levels of weapon system acquisition management. The pursuit of reliability and

maintainability must be a disciplined approach to the acquisition process rather than a set of practices and procedures.

In the past, the naval acquisition process has been characterized by emphasis on product performance, schedule, and initial procurement cost. In addition, production items have often been plagued with problems related to low reliability.

Due to the failure to meet reliability goals in the acquisition of major systems and subsystems, a decreased capability with increased maintenance costs has resulted.

To meet this reliability need associated with Navy contracting, many inovations in motivating the contractor have been pursued. One new contractual concept to improve reliability and maintainability has resulted in a new type of warranty contract--the Reliability Improvement Warranty.

D. RESEARCH OBJECTIVE

Based upon the increasing emphasis on Reliability Improvement Warranties as a means to reduce the cost of complex Naval Aviation weapons systems, a need exists to evaluate their potential for misapplication. Several studies have been accomplished on the RIW concept. Most data available concentrates on selection criteria, cost factors, and reliability improvement incentives. The authors believe that not enough attention has been given to the user of a RIW end item or the RIW interaction with other related military goals and objectives.

The objective of this research is to review past and present contracts to assess the impact of RIW on the Naval Aviation community from the operational support and supply point of view. The impact of managing a warranted asset at the fleet level, the risks posed to the contracting parties,

the opinions of fleet maintenance managers, and the fiscal benefits expected to be derived from RIWs are discussed.

II. METHODOLOGY

The many controversies involving Reliability Improvement Warranties were researched through an extensive literature review, and by personal and telephone interviews.

The detailed literature search began with a Defense Logistics Studies Information Exchange (DLSIE) review and a Naval Postgraduate School Library bibliographical search. The resulting lists led the authors to numerous background and historical materials, but many of the references were outdated. Numerous RIW studies of the government's and contractor's risks, costs, and reliability growth, had been performed by ARINC Research Corporation. However, these studies seldom addressed the Navy's strong concern over dependency upon the contractor, program administrative costs, cost and impact of transition to organic maintenance at contract expiration, and configuration control.

Mr. Oscar Markowitz, head of the Naval Aviation Supply Office's Technical Section until 1979, authored most of the Navy's literature on RIWs. His prolific writings were a valuable source of background and history regarding the Navy's RIW efforts.

To identify all the elements impacting on a RIW's effectiveness and fill in the gaps in the available literature, the authors chose a bottom-up approach. Interviews were conducted at organizational and intermediate maintenance and supply support levels. Depot level managers provided insight and evaluation from both the organic and commercial sectors. Fleet level maintenance and logistics managers were queried about their experiences with RIW contracted equipment. These interviews provided valuable information about the RIW's impact on the operating forces.

The authors also interviewed many persons involved with RIW contract policy, evaluation, and administration. Sites visited included the Naval Aviation Supply Office (ASO)--Philadelphia, the Naval Aviation Logistics Center (NALC)--Patuxent River, and the Naval Material Command (NAVMAT) and Naval Air Systems Command (NAVAIR)--Washington, D.C. These interviews added a top-down view of RIWs from persons variously responsible for:

1. Contract data collection and evaluation.
2. Level of repair and support policy recommendations.
3. Monitoring the performance of fleet assets.
4. Improvement programs for existing assets and support systems.
5. Planning maintenance policy and support system requirements for new weapons systems or equipments.

Ideas and experiences were also solicited by telephone from the Air Force Logistics Command, Naval Air Test Center, Naval Avionics Center, ARINC Research Corporation, and selected program managers and government contractors.

The experiences and concerns of individuals who interact with RIW assets and contracts are presented alongside the current literature views of RIWs throughout this thesis.

III. BACKGROUND

A. GENERAL

For a number of years the Department of Defense and the Navy have attempted to improve equipment reliability and maintainability and reduce costs by developing and applying new procurement concepts. Some examples include formal reliability and maintainability requirements, incentive contracting, value engineering, system effectiveness requirements, life cycle cost analysis, design-to-cost and preplanned product improvement [Ref. 4]. While it is difficult to assess the full impact of each concept, their continued use to varying degrees provides some rationale for concluding that these approaches have been somewhat successful.

Comparative studies of commercial airlines and military avionics equipment show that the airlines generally experience better reliability and maintainability. One reason the airlines have been successful at acquiring protection against low reliability is through the extensive use of long-term warranties [Ref. 5]. Such warranties obligate the contractor to provide maintenance services over a warranty period or reimburse the airline for necessary unscheduled maintenance. The warranty has become an important tool for extending the contractor's responsibility into the operational time period of his equipment.

The commercial acquistion environment may not be experienced in the military sector, yet many DOD officials believe it possible to adapt the warranty approach, hoping to realize the benefits of committing the contractor to produce the promised reliability. Several Navy programs are trying

the warranted approach under the present terminology of Reliability Improvement Warranty (RIW).

RIW provides an incentive to contractors to design and produce equipment with low failure rates as well as low costs of repair. It provides for the repair or replacement of failed units for an extended period of time (two to five years) for a fixed, up front cost. The RIW is used mainly in the marketing of high technology equipments which require a life cycle costing (LCC) approach to item procurement.

The terms Life Cycle Costing (LCC) and Failure Free Warranty (FFW) are both related to the RIW concept. These terms are here defined and their interrelationships explained.

B. LIFE CYCLE COSTING

Life Cycle Costing is an acquisition method in which the overall acquisition price considers operations, maintenance, and other costs of ownership. The objective is to insure the lowest possible program cost to the government during the life of the equipment. The total life cycle cost from conceptual design to retirement is considered and all costs are given equal attention. Approximately 70 percent of a system's LCC is determined by the procurement concept chosen to meet the mission need. Money spent during the early stages of program development has a leverage effect on the downstream costs and can save a great deal of money over the life of the system.

A broad range of acquisition concepts are usually solicited from the industrial community and DOD activities to influence a program's life cycle cost. This competitive approach provides a wide variety of concepts from which to select the most feasible method for fulfilling the mission need, while providing alternative performance levels,

schedules, and cost estimates from which to make performance, cost, and time tradeoffs. [Ref. 3]

C. FAILURE FREE WARRANTY

An early procurement concept used in life cycle costing was the Failure Free Warranty. It was one of the first attempts at a long-term service warranty directed towards increasing field reliability. FFW was first introduced in 1967 by the Lear Siegler Company [Ref. 6]. The nomenclature caused confusion and the program name was misleading because it was defined differently than the title implied.

FFW was not a guarantee that equipment would never fail and there was nothing free about it. Including a FFW clause in a contract raised the initial acquisition price by about ten percent [Ref. 7] and did not protect the buyer from shoddy, defective, or nonconforming material. It was a warranty of performance as measured by reliability [Ref. 8].

To avoid confusion and errors, the name FFW evolved into the Reliability Improvement Warranty.

D. RELIABILITY IMPROVEMENT WARRANTY

A Reliability Improvement Warranty (RIW) is a fixed price commitment that obligates the contractor to repair or replace, within a specified time, all warranted equipment that fails during the period of coverage. The objective is to provide the contractor an incentive to increase reliability by allowing him to maximize his profits.

The RIW is a form of warranty that is consistent with current Defense Acquisition Regulation (DAR) requirements. The Office of the Secretary of Defense [Ref. 9] describes the RIW:

> A Reliability Improvement Warranty is a provision in either a fixed price acquisition or fixed price equipment overhaul contract in which:

a) the contractor is provided with a monetary incentive throughout the period of the warranty to improve the production design and engineering of the equipment so as to enhance the field/operational reliability and maintainability of the system/equipment; and

b) the contractor agrees that during a specified or measured period of use, he will repair or replace (within a specified turnaround time) all equipment that fails (subject to specified exclusions, if applicable).

The method employed by the contractor to reduce his costs depends upon the nature of the particular contract. It may involve improving the reliability of the equipment, or reducing maintenance, cost of repairs, or turnaround time. [Ref. 10]

The incentive to improve operational reliability and reduce repair costs is created by stating in the development contract that a warranty will be required in the production contract. When bidding for the production contract the contractor will bid a fixed warranty price based on the estimated reliability and expected number of equipment returns.

In a RIW the contractor agrees to repair all failures as contracted under the warranty. If reliability is poor the contractor will not realize his expected profit since the increased failure rate increases his repair costs. If an increase in reliability is experienced his repair costs will decrease and profits increase. No explicit level of Mean Time Between Failure (MTBF) is stated in the contract and the incentive is based upon the profit motive alone.

RIWs are sometimes combined with a guaranteed MTBF. The same incentives exist, but if the contractor cannot attain the guaranteed MTBF additional costs or penalties are assessed. Since the contract is calculated using an expected MTBF the contractor must meet the goal in addition to simply balancing repair and modification costs. The RIW with guaranteed MTBF gives the government greater control

over life cycle costs and places the burden for a major portion of these costs on the contractor, who can affect them. [Ref. 11]

TABLE I

Recent RIW Applications

Equipment	RIW	RIW/MTBF
U.S. Navy		
APN-194 Altimeter	x	
AJB-3 Gyro	x	
AP27V F-14 Hydraulic Pump	x	
APN-99 Omega Receiver	x	
AYK-14 Computer	x	
APN-154 Radar Beacon	x	
PV3-044-029 Hydraulic Pump	x	
AVQ-24 Head Up Display Set	x	
APN-194 Radar Altimeter	x	
APN-141 Radar Altimeter	x	
RT-868/APX-76		x
RT-988/A		x
LD-6 Mechanical CSD	x	
RT-793/ASQ	x	
RT-743/ARC-51-A	x	
RT-546/ASC-19X	x	
RT-988/APX-76	x	
RT-868-B	x	

This table lists the applications of RIW contracts to U.S. Navy Weapon Replaceable assemblies (WRAs) since 1967. Systems are annotated as to incorporating a RIW, or a combination RIW with a Mean Time Between Failure (MTBF) guarantee. [Ref. 5, 12, 13, 14, and 15]

Because the RIW concept forces the manufacturer to consider reliability and maintainability in terms of profit from the start of the contract, the military finds the approach useful for many procurements and the number of applications is increasing. As with most new concepts there is a danger of misuse or excessive application. Table I lists U.S. Navy RIW contracts.

IV. HISTORY

A. FFW/RIW

The RIW concept came to life in the Navy in 1967 as a Failure Free Warranty (FFW). It's major proponent was the Technical Division of the Aviation Supply Office (ASO) in Philadelphia. The name Reliability Improvement Warranty (RIW) was subsequently chosen as a better descriptor of the concept. The two names were used interchangably until about 1976, when FFW was dropped from use, and RIW was exclusively adopted.

B. NAVY PROJECTS

1. AJB-3 Gyro

FFW was first applied to the AJB-3 Gyro installed in the A-4 and F-4 aircraft [Ref. 16] as a trial Navy program in 1967. In July of 1973 the contract was renewed for another six years [Ref. 17], and expired in 1979.

2. ABEX Hydraulic Pump

In April, 1973, the Navy signed a contract for an RIW F-14 Hydraulic Pump with ABEX Corporation [Ref. 18]. The mid-contract evaluation report [Ref. 19] released by ASO in October, 1977, was very positive and recommended the further use of RIWs by ASO. In April of 1979, the ABEX hydraulic pump contract ended. Although no end of contract report was completed, the contract was renewed until April, 1983 [Ref. 15].

3. NARF, RAMPART, and DRAP

The Naval Air Rework Facility (NARF), North Island, California, propcsed an organic RIW for two pieces of receiver/transmitter equipment [Ref. 20] early in 1975. This offer proposed a three year RIW to NAVAIR and included a MTBF guaranty. NAVAIR and ASO felt that the proposed equipments were not the most suitable for RIWs, so the proposal did not result in a contract.

The Navy's first organic RIW program, Project RAMPART, began at NARF, North Island, on 24 September, 1975. This project was a follow-on from NARF's first RIW proposal earlier in the year, and consisted of overhauling the APN-141 Radar Altimeter. [Ref. 12]

NARF expanded the original RAMPART program into the Depot Reliability Assurance Program (DRAP) in 1977. One of the equipments added at this time was the RT743B/ARC-51 [Ref. 21]. The program was highly successful in improving the reliability and increasing the MTBF of the fleet's assets. In early 1982, NARF North Island began phasing out the DRAP program, because the covered assets were scheduled for retirement and were being replaced by more modern equipment [Ref. 21]. NARF had determined that at this stage of the burn-out portion of the equipment's life cycle, reliability improvements were no longer significant enough to be cost effective.

4. Other Navy Projects

A list of potential RIW equipments was identified by the Navy early in the F-18 program, but as late as March, 1976, NAVAIR was still urging McDonnell Aircraft Corporation to get on with their preliminary F-18 RIW planning [Ref. 22].

ARINC Research Corporation recommended to NAVAIR six equipments on the CH-53E that were prime candidates for RIW contracts [Ref. 23]. This was the first time (October, 1976) that ASO had not spearheaded the selection of RIW candidate systems.

ASO proposed a list of General Electric F-404 engine parts for consideration as RIW candidates in November, 1978. This would have placed their repair in the contractor's hands vice NARF North Island's, who was then campaigning for Complete Engine Repair (CER) of the F-404 [Ref. 24]. The RIW did not come about, and NARF won the organic, non-RIW repair contract. In July, 1981, General Electric offered the Navy the same RIW on the entire F-404 engine (for the F-18) that they had offered to the Austrailians [Ref. 14].

C. AIR FORCE EXPERIENCE

The Air Force first tested the RIW concept in their acquisition process in 1969 [Ref. 25]. They began a formal trial RIW program in July, 1974, and published a set of guidelines [Ref. 26] for RIW contracting.

In 1980 the Air Force gave the RIW a new twist by contracting for an Availability Guarantee during FY1980/81 for their Air Launched Cruise Missile (ALCM) [Ref. 27]. This RIW was written so that the reliability of the ALCM was measured by it's success at passing preventive (static) maintenance testing, and the ALCM's operational record during test, practice, and training live firings. The contractor agreed to a specified reliability, and was obligated to solve any problems causing reliability degradation and retrofit the solution into existing ALCMs under the RIW. The second production lot of the Air Force's Advanced Medium Range Air to Air Missile (AMRAAM) was to be placed on a type of availability warranty similar to the ALCM's RIW [Ref. 27] in May, 1981.

Pratt & Whitney Aircraft signed a RIW in October, 1980, on the F-100 engine's high pressure turbine. The Air Force also signed with General Electric for an RIW on the entire TF-34 engine in January, 1981 [Ref. 13]. Feeling the heat of the competition with General ELectric, Pratt & Whitney Aircraft offered to the Air Force an RIW for the entire F-100 engine in March, 1981 [Ref. 14].

D. FUNDING AND MANAGEMENT

During the FFW/RIW developmental period, their purchase was made difficult by funding regulations because of the multi-year, fixed price characteristics of the contracts [Ref. 28]. Maintenance could not be purchased with procurement funds, and could only be budgeted on an annual basis. In response to a Government Accounting Office report on Life Cycle Costing and an ARINC Research Corporation report on long-term warranties, the Assistant Secretary of Defense specified in August, 1973, which funds applied to FFWs.

At this time, a memorandum within ASO indicated that "NAVMAT (MAT-02) has the ball for Navy representation" regarding FFWs [Ref. 29]. This shifting of responsibility for FFWs from ASC to the Naval Material Command does not appear to have actually happened. The researchers were unable to discover why this change was indicated, and why it subsequently did not occur. ASO definitely remained the focal point for the Navy's FFW/RIW programs.

One year later, DoD published a memorandum regarding the trial use of RIWs when acquiring electrical equipment [Ref. 30]. This memorandum expanded further on the avenues of funding RIWs. In June, 1975, the Technical Division of ASO requested to be placed in charge of fiscal planning for RIWs. The multi-year funding aspects of RIW contracts required a watchful eye and long range budget planning to assure their effectiveness.

Also at this time a report was presented by the Naval Weapons Engineering Support Activity to the Plans and Programs Office at NAVAIR (AIR-01), entitled: Techniques For Selecting and Analyzing Reliability Improvement Warranties [Ref. 31]. This was designed as an aid to help program managers in identifying and evaluating RIW candidate systems. Also promulgated in June, 1975, was a Chief of Naval Material letter to all commands titled: Trial Use of RIW [Ref. 32]. This letter served as notice that NAVMAT was supportive of the RIW concept.

The Technical Division of ASO drew up the first "Failure Free Warranty Plan" in October, 1975. It was approved by ASO in March, 1976, and provided a basis for including FFW/RIW considerations as they would impact the FY77 and future years budget considerations [Ref. 33]. Also in March, the Office of the Secretary of Defense released a memorandum concerning budgetary planning for RIWs [Ref. 34]. This memorandum defined the FFW/RIW as the procurement of a reliability improvement plan, instead of the procurement of maintenance. This was a major step in making the funding of RIWs both more acceptable and easier to accomplish within the DoD budgeting and acquisition systems.

The Navy has averaged about seven RIW contracts in force at any given time since 1973, and the recent surge of contractors offering RIWs has increased the Navy's interest. During July of 1982, the Technical Division of ASO had begun efforts to staff up, to enable them to better monitor the performance of the Navy's RIWs.

V. RIW IMPACT ON CONTRACTING PARTIES

The seven sections of this chapter deal with the impact of Reliability Improvement Warranties upon the contracting parties. Section's A through G are titled:

1. Contractor Motivation and Initiative
2. Risks
3. Warranty Price
4. Dependency
5. Configuration Control
6. Administrative Complexity
7. Transition to Organic Repair

A. CONTRACTOR MOTIVATION AND INITIATIVE

The use of fixed price warranties, as a method for assuring the continued operation of an item, is not a new concept. Everyone, at some time has received a warranty or purchased a maintenance agreement along with a television set, stereo, washing machine, or electric appliance.

In the business world, it is common to contract for maintenance on computers, copying machines, or typewriters. By so doing, we assure ourselves that we will not be confronted with an unexpected repair bill. What we have chosen to do is wager that the price for repairs we might later have paid without the warranty, is greater than the price of the warranty. On the other hand, the producer has wagered that his repair actions will cost less than we paid for the warranty, resulting in a profit for himself.

The warranty concept is thus a hedge against maintenance costs. Using this reasoning, many military acquisition managers have begun to utilize the RIW as a means of

controlling maintenance costs. Their belief is that warranties can provide significant benefits in the management of life cycle costs.

The major difference between a standard contract and a RIW approach to LCC management is that a standard contract attempts to control support costs by paying close attention to the equipment factors that influence these costs. One recognizes that the frequency of equipment failure and the expenses involved in repair are prime determinants of support cost. Therefore, demands or specified minimum levels of reliability and maintainablility (R & M) are placed on the equipment based upon the relationship between support costs and R & M. Typically, in this standard approach, it is believed that by controlling these characteristics, support costs are controlled.

In fact, however, the contractor controls the R & M which is built into the equipment. Operation and support costs depend largely on contractor effort during design, development, and production, and there is a definite increase in cost associated with higher levels of reliability.

While reliability is recognized as an important equipment characteristic and it's value is specified as a contractual requirement, reliability demonstration testing is not as accurate as other equipment parameter tests, and is time consuming and expensive. There is also disagreement concerning environmental conditions and what constitutes a failure. One of the Navy's roadblocks in contolling LCC is that the contractor has little economic motivation to improve the equipment characteristics which impact the support costs. Additionally, the lack of definitive reliability testing creates uncertainty about the contractor's success at meeting the contract specifications.

Now, by using a RIW, the Navy places responsibility for LCC with the contractor, who can better control costs. The contractor must bid on providing a specified number of equipments and effecting all repairs according to established performance requirements. If the contract requires that all malfunctions be contractor corrected, the Navy avoids having to define what constitutes a failure. With this RIW approach, a significant change is made in responsibility for LCC management. The burden for a major portion of LCC management is shifted to the contractor, who must now concern himself with the operational and support costs in addition to the production costs. His responsibility does not end when production is discontinued. He must make modifications and improvements in the product to correct malfunctions and meet reliability improvement goals in order to reduce his repair frequency, and thus reduce his costs.

The theory behind RIWs is to provide the proper motivation to both buyer and seller with the goal of reducing LCC.

B. RISKS

In recent years, most purchases of military equipment included a warranty in accordance with the Armed Services Procurement Regulations (ASPR). Warranties addressed the correction of latent defects of supplied material. The warranty period was generally one year or less, and equipment often remained unused until much of the period expired. The reliability improvement warranty typically covers periods of three to five years, greatly expanding the opportunity to assure that equipment functions properly when finally placed in use. This longer term carries with it a greater risk for the contractor.

Under the terms of a RIW, the equipment producer, charging a fixed price, assumes responsibility for certain types of repair services for the warranted equipment over an extended period. His profits are reduced with each unit returned for warranty service, thus the contractor must determine how much to invest in design and production to achieve a product with a level of reliability that will maximize profits. If an unexpected reliability problem arises, he must decide between investing in design changes to eliminate the problem from the equipment, or investing in repairs of the problems as they occur.

While the use of long-term warranty contracts has the potential for favorable results, the data available and the low number of programs have not been sufficient to permit firm conclusions about RIW effectiveness. Currently, at ASO's Technical Division where contract evaluation is performed, emphasis on evaluating RIW contracts has been relaxed. Since the retirement of the offical who headed the Division for twenty years, the RIW information data base has been slow in accumulating. For example, in 1977 the section completed a mid-contract evaluation of the F-14 engine ABEX hydraulic pump. This RIW contract was completed in 1979, but the final contract evaluation report was still pending in September, 1982. Individuals at ASO explained this delay of the contract evaluation as a result of revised priorities and personnel turnover and losses. Although it is not to be construed that the contract between ASO and ABEX Corporation was not profitable for both concerns, the effectiveness of the contract cannot be assessed without a timely data base, and an organization actively performing the analysis.

In search of a DoD wide RIW information data base, the authors discovered many references to a joint Air Force/Industry Product Performance Agreement Center (PPAC) [Ref. 35]. The PPAC, established at Wright-Patterson Air

Force Base, Dayton, Ohio, is to serve as a DoD/Industry clearinghouse for product performance data and analysis. This center is a response by the Air Force Systems Command and Air Force Logistics Command to the extended use of innovative warranties emphasizing product performance and reliability. The center, which was to be operational by mid-1982, is to aid in determining the effectiveness of existing warranty agreements, centralize a warranty data base, and suggest improved ways to use warranties. The PPAC is not a reality yet, and is presently a collateral duty for a single individual in the Air Force Logistics Command [Ref. 36]. This situation is similar to the one at ASO in that RIW effectiveness is difficult or impossible to measure due to the lack of assets available.

The authors fear that RIWs may have achieved a fad status, and that not enough thought has been given to applicability and tailoring. There is also a genuine regard that the RIW concept itself may be inappropriate for military equipment because of reduced military self-sufficiency and the risks posed to industry. During an interview conducted at the Naval Air Test Center, considerable concern was voiced over the increased potential for the use of RIW as a cureall to the reliability problem. The authors' sources felt that reliability may have become the overriding concern in the acquisition process, while pushing maintainability to a much lower priority. [Ref. 37]

Specific examples and the thoughts of fleet maintenance managers are discussed in the Dependency section of this chapter.

Some of the common risks to RIW contracting parties are:

1. Government risks:
   a) RIW price; The government may pay too much for the warranty coverage.

b) Dependency; Long-term dependence on contractor support will reduce military self-sufficiency, especially if strikes occur at the contractor's plant, or the contractor resolves to discontinue support.

c) Configuration control; The contractor may use the design that is most amenable to his warranty maintenance, but is not the most appropriate for military repair following transition.

d) Transition; The transition from RIW coverage to organic maintenance introduces a number of administrative and logistics problems.

e) Administration; The warranty concept introduces greater complexity into the military logistics system. The equipment on RIW cannot be supported through established supply channels.

f) Contractor performance; The contractor may not perform well because of high repair costs, losses, contract interpretation, loopholes, or he may set his priorities on other business.

g) Decreased equipment usage may cause decreased failure exposure. The Navy would not receive the number of repairs or improved reliability that it had already paid for.

h) Mishandling or tampering by Navy personnel might cause failures beyond contractor control, and void the warranty for those items.

2. Contractor risks:

a) The contractor may not estimate the frequency of failure accurately enough to make his planned profit.

b) Equipment may be subject to unforeseen operational and environmental stresses, causing it to fail more often than planned.

c) Increased equipment usage may cause increased failure exposure.

d) The contractor may bid too low a price due to competitive pressures, optimistic R & M estimates, or misinterpretation of provisions.

e) Slow government processing of R & M Engineering Change Proposals (ECPs) might hamper the reliability improvement process.

f) The inflation rate may exceed planned levels, affecting parts, labor, material, and overhaul costs.

In addition, contractors using RIWs may suffer lost sales and profit because they are foregoing the opportunity for additional income from future contracted ECPs, spare parts, or contracted maintenance [Ref. 38]. Detailed risk evaluation follows in this chapter.

C. WARRANTY PRICE

Price is the major risk to the Navy in a RIW contract. Conceptually, the additional cost of the RIW plus the basic contract cost should equal less than the cost of the Navy's organic maintenance plus future possible improvement contracts plus the basic contract cost.

A RIW price model, presented by ARINC Research Corporation in a study prepared for the Air Force, was based on the formula in Figure 5.1 [Ref. 39]. In this formula, the risk factor is the single parameter encompassing the uncertainties associated with determining failure rates, predicting total operating hours, and estimating cost of repairs and number of no-defect returns. These uncertainties relate to considerations such as contractor experience, adequacy of test provisions, confidence in reliability growth prediction methods, and degree of conservatism in

RIW PRICE =

$$\left[D \times R \times P \right] \times \left[\left[C/R \times ENR \right] + \left[C/G \times ENG \right] + \left[DC/Y \times YRS \right] + \text{Warranty Data and Administrative Costs} \right] + \left[FC \times R \times P \right]$$

Where:

D = Discount Factor
R = Risk Factor
P = Profit Factor
C/R = Cost Per Repair
ENR = Expected Number of Repairs
C/G = Cost Per Good Return
ENG = Expected Number of Good Returns
DC/Y = Other Direct Yearly Costs
YRS = Number of Years of Warranty
FC = Fixed Direct Costs

Figure 5.1 RIW Pricing Formula.

performance, specifications, schedule, and unit price. This risk factor has a considerable impact upon the price of the contract.

It is the assumption of the buyer that such risk uncertainties can be best overcome by using fixed price contracts which motivate the contractor by allowing him to achieve a maximum profit. The problem arises, however, that the amount of risk, not profit, is the overriding concern for a contractor. Contractor representatives consistently mention risk aversion as the most important reason for their willingness to negotiate profit and cost sharing fractions in incentive type contracts rather than the government's preferred fixed price arrangements. [Ref. 40]

A representative of a major defense contractor stated that risk must be reduced before a contractor can afford to assume the role of a profit maximizer. If the contractor is forced to accept a fixed price RIW because of provisions in the production contract, which may not have been in the development contract, he will provide for as many contingencies as possible. This is especially true in the absence of competition when the contractor who developed the system then moves into production. The contractor will price the RIW high enough so as not to later jeopardize his profit position. [Ref. 41]

A recent study reported that industry felt providing a good product was by far their most important objective. Secondary objectives were developing a long-term relationship (survivability), improved cash flow, profit, and development of new capabilities. [Ref. 42]

When engaging in a RIW contract, the contractor will cover all his risks. "Since the price is determined by the contractor, he is able to reduce his risk to a point of his choosing." [Ref. 39]

Due to the difficulty in projecting and predicting failure rates and potential reliability improvements, it is often difficult to assess the risks in order to accurately price a RIW. For this reason, the Navy risks paying too much for a warranty in the event the system performs better than expected.

Even if the RIW is contracted at a fair and reasonable price, misgivings have been expressed about other factors which may cause the RIW to be a disadvantage [Ref. 37]. For example, in discussions with fleet personnel, many felt that RIWs may have lead to increased costs. One reason cited was that maintenance was being performed at the component or weapon replaceable assembly (WRA) level rather that at the internal module level. If lower than expected reliability results in a large number of failures, the cost of component spares required to maintain the pipeline may make RIW support uneconomical for both parties. In addition, the built in test equipment needed to fault isolate discrepancies to specific WRAs has added to the cost of RIWs.

The expected usage rate of an item is an important consideration in pricing. Equipment that remains dormant for unanticipated long periods of time will not make use of the repairs and upgrading that has already been paid for by the RIW. Funding cuts, changes in mission requirements, or poor reliability of other systems may result in underutilization of an RIW item.

An example of such a problem was the Air Force's contract for a gyroscope on the F-111 aircraft. Airframe problems reduced the number of flight hours from that anticipated, causing much lower utilization of the gyros during the warranty period.

The use of a RIW stems from the belief that reliability improvement is important. If this belief is to be realized the initial number of items covered by the warranty must be

large enough to motivate the contractor to invest his capital in improvements. A RIW system which is subjected to budget cuts or other interruptions may change the contractor's intent from one of reliability improvement to one of retrograde repair only. For example, a contractor faced with making repetitive avionics system repairs involving only bit piece replacement over a limited number of assets, would not be motivated to invest in expensive engineering change proposals. The contractor could ride out the contract, making only limited repairs within the contracted turnaround time at minimal expense. [Ref. 43]

The question as to whether or not RIWs are worth the price remains to be answered. ASO and ARINC Research Corporation have performed several conceptual studies which indicate that significant cost savings result when items under RIW are compared with projections of similar items not covered by a RIW. In a recent case study of four RIW contracts [Ref. 44], many common characteristics were found among the programs. The key points were:

1. The result of most of the programs indicated a definite increase in MTBF.
2. In three of the four cases, many problems plagued the contracts.
3. In three of the cases, other factors not related to the RIW contributed to the improvement in reliability.
4. In all cases the actual cost involved could not always be agreed upon.

The contracts presented in the case study were:

1. Navy AJB-3 Gyro (Lear-Siegler).
2. Air Force F-111 Gyro (General Electric).
3. Navy F-14 Hydraulic Pump (ABEX).
4. Navy AN/AYK-14(V) Standard Airborne Computer (Honeywell).

With such dichotomy existing between these contracts, serious questions may be raised as to the cost effectiveness of RIWs when compared to other methods of improving reliability.

In another study conducted to compare organic maintenance with contractor maintenance involving Air Force satellite equipment, the analysis of the RIW option suggested that it offered only a slight economic advantage over organic maintenance [Ref. 11].

One researcher encountered considerable doubt among Navy R & M personnel regarding the motives of contractors. They felt contractors could hold back on initial equipment reliability while profiting on the production contract. They could then earn substantial profits by quickly improving the reliability to meet the contracted improvement goals. [Ref. 44]

D. DEPENDENCY

Naval aviation maintenance traditionally involves three levels:

1. Organizational
2. Intermediate
3. Depot

Maintenance actions are identified as either preventative or corrective. Preventative actions seek to prevent failure while corrective actions attempt to repair a failed piece of equipment.

The evolution of electronics from discrete components to integrated circuits has fostered the implementation of a modular replacement maintenance philosophy in the event of equipment failure. This philosophy was pursued while the availability of resources declined during the 1970's. It resulted in many system's organizational and intermediate maintenance levels being limited to the performance of only routine preventative maintenance functions and replacement of failed modules. Corrective maintenance actions on those modules have become a depot level only responsibility.

Usurping the intermediate level's repair capabilities reduces the maintenance program to a two-tiered system connected by a logistic distribution pipeline that is growing in length and diameter. "Combat engagements would quickly sever this 'umbilical to the beach'". Admiral Isaac C. Kidd used this phrase to describe the supply- and depot-level maintenance pipeline during his tenure as Chief of Naval Material [Ref. 45]. Increased use of commercial depot maintenance (RIW), has removed the fleet even further from their support sources.

The concept of RIW as a commercial depot level repair works only if the manufacturer receives the retrograde item back in his facility. This allows the contractor to make the required engineering studies in an attempt to determine what can be done to improve reliability. This of course precludes the Navy from effecting repairs and acquiring experience in supporting it's weapons systems. Many RIW critics believe the Navy may become too dependent upon the contractor.

In one interview [Ref. 46], a fleet maintenance manager expressed his concern over the increased use of contractor support for fleet assets. He believed the Navy risked becoming dangerously dependent upon contractors for repair of operational assets, and indicated that a lack of fleet repair capability might seriously degrade remote or independent operations. He suggested the possibility that contractors dealing with new technology may tend to maneuver themselves into a position of becoming the only source of repair. Among many fleet level managers, the belief surfaced that the Navy's shipboard maintenance capability is being inadvertently taken away. The fleet's widespread policy of accomplishing most tasks at the lowest economical level of the command structure may have been circumvented by certain acquisition concepts involving contractor maintenance, such as RIWs.

When considering a RIW candidate, a detailed Logistic Support Analysis is performed to determine a sufficient sparing level so that factors such as Mean Time To Repair (MTTR), Turn Around Time (TAT), Mean Time Between Failure (MTBF), etc., will have minimal effect on readiness. Several unplanned events might happen, causing the number of spares to be inadequate. Events such as strikes at the commerical overhaul sites, freight embargoes, severe weather, natural disasters, or enemy attack, would impact heavily on fleet readiness.

For example, the commercial facility overhauling the Magnavox AQA-7 DIFAR system (not RIW) severely degraded readiness when workers in the production and repair operation went on strike. Since the contractor warranty required the return of all retrograde assets to the manufacturer's plant, the assets piled up on the contractor's loading dock until negotiations settled the labor dispute. [Ref. 47]

The situation may be aggravated further if such events as just described are incorporated into the exclusion clause of the RIW. When such unpredictable events occur, the contractor is not responsible for meeting the time constraints for item repair and return that is otherwise enforceable under the contract. Exclusion clauses remove the pressure from the contractor to meet contract requirements through sub-contracting, alternate transportation, etc. As included in one contract, delays attributed to events beyond the control of and without fault or negligence by the contractor are not counted in the RIW turnaround-time calculations [Ref. 48]. Pipeline delays are of major concern to fleet maintenance managers, but the RIW does not cure this ill.

Some of the exclusions written into a RIW exclude damage caused while in the possession of the Navy due to the following:

1. Fire or Explosion
2. Submersion or Flood
3. Aircraft crash or Combat damage
4. Tampering by government personnel (seal breakage)
5. Physical damage caused by accidental or willful mistreatment.

Items four and five are frequent occurances. Tampering by maintenance personnel is often done by personnel who are unaware that the unit is under a RIW, or realize the item is warranted, but do not understand the rules of the game. Tampering also occurs by direction of the technician's superiors in a desperate attempt to RFI (Ready For Issue) the asset in order to get a system operating again [Ref. 49].

The RIW concept depends upon shipment of the retrograde equipments to the contractor through normal supply channels. When operating at sea for long periods of time and at extended supply lines, contractor maintenance can have a detrimental effect if adequate spares are not available on-board the ship. Furthermore, the Naval Supply System does not have a specific asset management program, such as the Closed Loop Aeronautical Management Program (CLAMP), to expedite RIW retrogrades through the system. Given the fact that the contractor's turn-around time is calculated only from the time an asset arrives on his loading dock until the time it is made ready for shipment, lengthy and unacceptable turn-around times are usually not a result of contractor inability, but caused by extended logistics channels. For this reason, persons interviewed at the Naval Material Command were opposed to RIWs for support of surface and sub-surface forces. [Ref. 49]

No pro RIW feeling for the use of RIWs as a means of increasing reliability could be obtained from interviewees at NAVMAT. One previous researcher was told by a Navy reliability and maintainability expert:

My policy is that I am not against warranties or guarantees if we can get them (from contractors). Reliability Improvement Warranties, in the strict definition, are current gimmicks, with which some think we get something for nothing. Others think we get nothing for something (with RIWs). I think RIWs are somewhere in between. [Ref. 44]

Most engineers at NAVMAT felt RIW connotated that a system initially was not designed properly. They felt that if the money was put up front to design a system properly and that adequate competition was available to maintain design inovation, you would not need RIWs. [Ref. 44]

Another problem created by the use of RIW is that of assessing the contractor's ability to meet surge requirements in the case of a sustained conflict or war. Critics of full commercial depot level maintenance, such as RIWs, believe the only means to insure surge maintenance capability lies with organic depot facilities. Their reasons are:

One, since a full wartime support capability is required, only a government depot could be required and counted on to retain such a reserve capability at all times. Two, since government depot employees are not allowed to strike, critical support of weapons systems would be assured at all times. Three, since government depots are under full government control, they cannot refuse to do some work on the grounds that it is not economical to do so. [Ref. 50]

For most existing weapons systems, the question of maintaining a surge repair capability is not usually a difficult one because contractor support has been used concurrently with in-house repair. However, with the use of long-term RIW contracting for new procurement, the military does not develop organic repair until long after the item has been in the inventory. As a result, the military loses control over ensuring surge capability exists because organic repair would have to start from square one during a crisis. A study reviewing the Air Force Inertial Navigation System

[Ref. 50] concluded that the contractor would be unable to meet generated surge demands. Even operating at 150 percent of his then current production level, the contractor would be unable to meet operational requirements. Conversely, if an organic maintenance capability had existed prior to the surge requirement, shortages might not have occured.

Although the study may or may not be applicable to other items under commercial warranty, one interviewee expressed deep concern over a contractor's unwillingness to respond outside the scope of his contract. Economic pressures, competing production lines, or skilled manpower shortages may affect the willingness or ability of a commercial overhaul facility to respond to surge requirements in the most economical manner [Ref. 43]. In contrast, organic military depot maintenance facilities stand ready to respond to fleet requirements.

From a readiness point of view, it is clear that DoD should maintain an industrial base capability to respond to surge requirements. Recent emphasis on productivity and readiness, such as the Aquisition Improvement Program's Action 3--Multiyear Procurement; Action 4--Program Stability; Action 5--Encourage Capital Investment to Enhance Productivity; and Action 32--Increase Competition in the Acquisition Process; all work to create a climate of greater program stability and more effective competition in which companies will vie for defense contracts. The Deputy Secretary of Defense emphasized the need to integrate industrial base productivity and DoD responsiveness issues, stating:

> We must weave industrial base considerations into the acquisition process, revitalize industrial preparedness planning, and show industry, through both planning and actions that industrial preparedness is an integral part of acquisition. [Ref. 51]

It is evident from recent changes to the DoD acquisition policy that the defense industry and military readiness are intimately dependent upon each other. More people are realizing that system support must be given equal attention when addressing other parameters such as cost, schedule, and performance. While it is imperative that defense contractors and program managers work together, the use of RIWs and the consequent exclusive contractor support cause many to question the necessity or the prudence of the RIW acquisition concept.

> The using commands naturally view this (RIW) as a loss of self-sufficiency. The accomplishment of their mission is more vulnerable to the economic health of the RIW contractor, to strikes, and to other vagaries of civilian commerce over which they have no control. [Ref. 11]

By properly executing the actions necessary to broaden the defense industrial base, as well as those actions required to maintain sustained fleet survivability, a fine line of balance must be achieved when utilizing contractor and organic maintenance.

E. CONFIGURATION CONTROL

Most military RIW applications have made use of standard configuration control practices or those defined in MIL-STD-480-- Configuration Control--Engineering Changes, Deviations, and Waivers; and MIL-STD-483-- Configuration Management Practices for System Equipment, Munitions, and Computer Programs. The objective is to assure that the configuration status of the equipment is known and is compatable with the intended maintenance concept as well as inter-system interface control [Ref. 39].

Contractor initiated engineering change proposals to improve the reliability and maintainability, at no additional contract cost, are encouraged under the RIW. Conceptually, the normal MIL-STD-480 procedures apply, with two exceptions:

1. The contractor must include his recommendation on incorporating the ECP into all government/Navy owned spares.

2. Each ECP will be automatically incorporated in the contract after 35 days, unless the contractor is notified of its nonapproval before that time.

The ECPs should be installed in all new production units and in all units returned for repair. To ensure that the entire inventory can be brought to a standard configuration at a reasonable price upon the completion of the RIW, the contractor may be required to submit a schedule of modification-kit prices that are effective through the RIW expiration date [Ref. 52].

Most RIWs require the contractor to maintain configuration control by serial number. All changes to design, configuration, parts, technical orders, or support equipment that are Class I changes, (affect form, fit, or function), must be submitted to the activity with design control for approval. Changes not affecting form, fit, or function, (Class II), are accomplished, documented, and reported to the program office in a timely manner. The intention is that RIW items returned for repair will be brought up to the latest approved configuration, unless otherwise specified. At the end of the RIW, any remaining RIW assets in the inventory that are not of the latest configuration must be modified by the government, using kits and information supplied by the contractor, at no additional cost to the government. [Ref. 48]

Although the contract may be written with the intent of providing maximum configuration control, many individuals involved with the management of fleet assets expressed

considerable skepticism regarding the configuration control issue. One engineer expressed his concern over the contractor's decision making ability with regards to form, fit, or function determinations. A basic precept of RIW contracting is allowing the manufacturer to make unsolicited design modifications. A potential problem arises, because the contractor's view of a change may be one with which the program officer does not agree. Design changes incorporated without proper coordination between the contractor's engineers and government experts can create serious problems. [Ref. 53]

One individual concerned with the logistics support of maturing weapon systems fears that the information concerning unmodified assets, as well as updated systems, might not be accurately maintained by the manufacturer. Concern was expressed over systems covered by RIW contracts which may not be receiving the necessary administration, resulting in varied and untraceable configurations within the inventory. Such a situation could cause overwhelming trouble during transition to organic maintenance. [Ref. 37]

Of the many issues related to RIW contracting, configuration control surfaced as one of the most frequently voiced complaints among logistics managers. The policy of allowing manufacturers to modify systems and components, except for external form, fit, or function changes, is contrary to a maintenance policy of standardization, and may jeopardize the military's ability to assume organic maintenance at contract expiration.

F. ADMINISTRATIVE COMPLEXITY

1. Organizational and Intermediate Levels

At the organizational level, RIW equipment requires additional failure documentation. The Navy's aviation Maintenance/Material Management (3-M) system does not provide failure information in a timely enough manner to meet the contractor's requirement for failure data to accompany each returned asset. The Navy's Visual Information Display System/Maintenance Action Form (VIDS/MAF) does not provide the detailed information that the contractor requires. When a RIW asset fails and is removed from an aircraft, the technician must complete a contractor supplied failure report in addition to a VIDS/MAF. The quality of the contractor's field failure data is therefore solely dependent upon the accuracy of the extra paperwork required of the aircraft technicians. Most fleet aviation maintenance managers agree that, in light of the operational tempo and manning level of Navy squadrons, even the normal VIDS/MAF load is an administrative burden. Imposing additional RIW documentation requirements upon the organizational level is detrimental to the accuracy and quality of the data provided. If RIW equipment is inducted into the Intermediate Maintenance Activity (IMA) for a contractor required test or fault determination, a similar specialized document is required.

2. Shipment and Supply

It is not uncommon for maintenance paperwork (VIDS/MAFs) to become lost during shipment. If this happens, the maintenance data can often be reconstructed by accessing the 3-M data base. The Navy keeps no such data base of the contractor's completed RIW failure reports. If the RIW documentation is lost, there is no backup method

available to reccup the information. Such a loss might prompt the contractor to diligently pursue the lost data, in a sincere effort to determine failure causes and improve his product's reliability. A contractor might, however, consider the item a non-failure because of the missing paperwork. He could then write off the asset's failure by making no failure entries in the data base. This action circumvents the failure's lowering the MTBF and avoids impacting the attainment of his reliability improvement goals.

Regarding shipment of failed units, the entire process can be very difficult because contractor supplied shipping containers are often required. Storage space is at a premium aboard ship, and the management of reusable containers has always been a difficult task. Organically maintained equipment can usually be safely crated for shipment in the event that a suitable reusable container is not immediately available. This is generally not possible with RIW equipments, which can only be shipped via contractor supplied containers. Any packaging latitude taken by the ship's personnel can void the RIW.

Amazing as it may seem, the Navy might not get it's moneys worth from a RIW by pure chance, depending upon the luck of the draw in a rotatable pool. Many avionics systems (black boxes) are held in a supply department rotatable pool. There are usually several assets of each type equipment, the number depending upon the historical usage rate. An organizational level technician brings his failed unit directly to the rotatable pool and, in a one-for-one exchange, receives an operational unit. If the asset's entire population is not covered by the RIW, there will be a mixture of RIW and non-RIW assets in the pool. Warranted assets will most likely never be given issue priority over non-RIW assets by the person managing the pool. Thus, a

component whose multi-year maintenance has already been paid for may sit on a shelf, while the component issued may soon fail, and require organic repair. This is clearly a very uneconomical practice. The Navy will not derive full benefit from a RIW unless the assets remain installed in operating aircraft.

There are no special supply channels set up to handle RIW equipment, which typically cannot be routed through normal channels. CLAMP (Closed Loop Aeronautical Management Program) personnel are often "conscripted" to handle and track RIW assets. The CLAMP administrator at NAS North Island was required to process NARF North Island DRAP equipments. Their staff was not increased to handle the load, causing major disruptions to the CLAMP unit's routine.

3. Contractor

The DRAP managers at NARF North Island conceded that they would be happy when the program draws to a close, because their staff had not been increased to handle the additional administrative requirements [Ref. 43]. A defense industry contracting officer related that the administrative burdens placed upon the contractor were massive. If his firm had their choice, they would rather never have to administer a RIW [Ref. 41]. Serial number configuration control and ECP incorporation status tracking were very tedious, labor intensive, and expensive.

4. Navy-wide RIW Management

Guaranties in general are difficult to administer because of the calculations required for MTBF determination.

> Not only must failed items be considered in the equation, but operating units as well. However, current reporting systems do not provide information on utilization of items that are still installed and operating. Therefore, any statistical estimate of the MTBF must be based on a small sample of the population. [Ref. 31]

This situation is partially avoided when the data for all equipment is keyed to unique serial numbers. Still, the installed assets will have accrued an unknown amount of operational time, and any numbers used in the MTBF calculation can be only estimates. An additional problem arises if ECPs have already modified some units and not others. The MTBF would then be based on a heterogeneous grouping of varying MTBF functions.

The authors spent considerable time telephoning program management offices and reading the literature, trying to isolate which equipments were RIW contracted; a current Navy RIW list does not exist. Although the Master Repairable Items List (MRIL) does identify RIW items as such, the items are not broken out. The only possibility would be to "try a special central computer run at ASO" [Ref. 53] to isolate them.

The fact that RIWs are managed by exception, rather than being institutionalized, makes their administration difficult. Currently, there is no designated central clearing point for RIW information where a program or logistics manager can get advice and policy consultation.

G. TRANSITION TO ORGANIC REPAIR

Prior to RIW expiration, the government must decide whether to renew the RIW contract for another period, or cease reliability improvement efforts. When equipment reaches the age and condition where reliability improvements are not cost effective, the choice is either to continue contractor maintenance, or transition to organic repair.

Even before the RIW contract is negotiated, analysis should provide some idea as to the best time to transition to organic support, and what the transition will cost [Ref. 54]. The authors did not discover a single case where

this had been done. As pointed out in this study, the government has seldom done this type of analysis to help decide whether to renew a RIW contract or transition to organic support. The only analytical projection of the optimum point in time to discontinue a RIW was performed by NARF North Island's DRAP managers.

1. Entire Population RIWs

When equipment transitions to full support organic maintenance, the provisioning data provided by the contractor is usually very accurate. In contrast, non-RIW acquisition support requirements are derived from very narrow data, based upon prototype equipment, with little or no field data. A more accurate determination of required spares and support parts can be made from the data gathered during several years of a RIW.

Repair methods and manuals may also be fairly well established. The Navy does not need to design the maintenance plan from scratch if good information has been purchased in the RIW. Unless the government is very careful and specific about transition aspects in the original warranty, the contractor's repair methods may be incompatible with existing Navy procedures and equipment. If the contractor uses very unusual or non-standard techniques, the transition costs for procurement of specialized equipment and skill training will be very high. The Navy, during the RIW negotiation, might prepare for transition by specifying that the equipment be manufactured and repaired using methods compatible with the available organic test equipment and repair methods. This is contrary, however, to one of the fundamental axioms of the RIW; the contractor should be allowed the latitude to take whatever steps are required to improve reliability. Suppose the Navy did in fact own some equipments required for test and repair of the RIW assets.

Unless these are supplied to the contractor as Government Furnished Equipment (GFE), they will lie dormant or underutilized, incurring a lost opportunity cost to the government.

Transition often gains the Navy little independence from the critical WRA pipeline. Few RIW equipments incorporate any type of intermediate maintenance, so transition involves a government depot facility replacing the commercial contractor. For the full population RIW, transitioning addresses only one facet of the force dependency problem. Deployed units will gain independence only if the Intermediate Maintenance Activities (IMAs) can take over some of the contractor's repair functions. The tendency to retain a two-tier maintenance policy (organizational/depot) after transition is easy to understand and, on the surface, appears cheaper. The long range cost effects of not incorporating the IMAs into the repair cycle bears closer study.

A mid-life cycle transition to organic maintenance contains hidden costs. For example, the life of a system might be fifteen years, utilizing a RIW for the first five. After transition, the government would realize only two thirds the utilization of their fixed plant (compared to full life cycle organic maintenance). Additionally, the Navy already paid fixed plant costs to the contractor in the RIW price. Although the RIW may stipulate that the contractor provide ECP kits, data, manuals and test and repair equipment during transition, these costs have also been included by the contractor in the RIW price. The fixed plant costs paid to the contractor cannot be recovered, resulting in the Navy paying for them a second time at transition.

2. Partial Population RIWs

When only part of the equipment population is covered by a RIW, the government already has repair methods, supply support, and training in place before the transition. Organic repair capabilities must then be expanded to handle the surge of additional equipments. Contractor-provided ECP kits must be installed in non-RIW equipments to bring the population to a common configuration. This twin load of greatly increased population and ECP kit installation may be a very heavy burden on the fleet.

The complete duplication of supply and support systems for the warranted and non-warranted WRAs is inefficient. This situation provides good surge demand protection, but the government pays a good deal extra to put the capability into the contractor's plant.

VI. DISCUSSION OF LESSONS LEARNED

This chapter presents some lessons learned from past and ongoing RIW contracts. These lessons provide a valuable insight into the use of RIWs and serve as a means for measuring their effectiveness. They also may be used to determine whether a RIW, as an acquisition and support concept, has been responsive to the needs of operational units.

RIW benefits are expected to be achieved by providing contractors with monetary incentives to improve equipment reliability and maintainability, thus reducing the number and costs of repairs. Two important requirements in determining the appropriateness of a RIW for a particular program are:

1. The concept should be cost effective.
2. The information necessary to assess the contractor's RIW effectiveness (e.g., Mean Time Between Failure) should be readily obtainable. [Ref. 55]

A. TIMELY DATA BASE

A 1979 audit, performed by the Air Force Audit Agency on three RIW contracts, found that a definite plan to evaluate the impact of the RIW concept had not been prepared. The audit concluded that the specific data to be retained had not been determined by the Air Force Logistics Command. Data that is identified for retention significantly influences the scope of any future evaluation, and the ability to assess the value of existing RIW programs may be reduced if data selected for retention are not based on the objectives of a master plan. The audit also concluded that adequate procedures must be developed for gathering and storing data.

After the Air Force audit was accomplished, the Office of the Secretary of Defense initiated actions to evaluate RIW effectiveness. A previous pilot tri-service RIW collection center was operated in late 1975, but was not continued beyond 1977. The Air Force is presently organizing a DoD/Industry wide clearinghouse for RIW contracting information. This Product Performance Agreement Center (PPAC) is intended to assist program offices in selecting and negotiating effective warranties and product performance provisions. The Center's intended use is to determine the effectiveness of existing DoD warranty agreements and to improve the use of future agreements. As revealed in Chapter V, the PPAC is unfortunately neither staffed nor operational at this writing. Additionally, current Navy RIW contract evaluation is almost non-existent. The Aviation Supply Office and NAVAIR are currently not analyzing RIW performance and contract effectiveness [Ref. 53] and [Ref. 56].

B. ADMINISTRATIVE COSTS

The full impact of the administrative requirements imposed by RIWs is not accurately considered in the life cycle cost model. The Air Force found in their audit of the AN/ARN 118 Tactical Air Navigation System, C-130 Omega Navigation Set, and the C-141 Altitude and Heading Reference System, that numerous RIW administrative and personnel costs were not considered in the analysis prior to contract award. For example, seven additional personnel (annual salary of $200,000) were required to accumulate and report RIW data. However, life cycle cost computations used to assess the cost effectiveness of RIW prior to contract award did not include these costs, which might have significantly influenced the decision of whether a RIW was the most cost effective contracting approach. [Ref. 55]

In the Navy's Depot Reliability Assurance Program (DRAP), numerous administrative hours were expended in attempts to track Pacific Fleet assets. A constant monitoring of each RIW component by serial number was required to prevent the migration of warranted equipments outside the Pacific Fleet. This type of strict management attention was not considered or costed out during the program's inception and development. [Ref. 43]

Also, increased management and administrative requirements at the organizational and intermediate level are not accurately addressed. Presently, the only means for an unknowing maintenance or supply technician to determine whether a component is under a RIW or not is by referring to the Master Repairable Items List (MRIL). Maintenance and supply support personnel are often unaware they are dealing with a RIW asset. Special procedures and additional education must be emphasized, together with appropriate increases in priority for handling and shipping of all RIW units.

C. POPULATION COVERAGE

An area that causes serious RIW management problems is population coverage. Many RIW contracts cover only a part of the equipment population by serial number or over a period of years. Rather than restrict RIW modules to specific warranted Weapon Replaceable Assemblies (WRAs), and subsequently warranted WRAs to designated warranted aircraft, the RIW permits a complete interchange to take place. For example, in the F-16 aircraft, a warranted module may be used to repair an unwarranted WRA, and that WRA can be used in a warranted aircraft. Such a situation also occured in the DRAP program. The most difficult management problem was preventing the migration of RIW assets out of NARF North Island's control.

Such possibilities create a potential gaming situation between industry and the military, and can cause numerous administrative difficulties. Thus, it is generally advisable to extend RIW coverage to an entire population for a shorter calendar period, rather that lengthen the period at the expense of not covering the entire inventory. According to an analysis of the F-16 program, the coverage period should always be long enough to assure a contractor that he has the potential for realizing economic benefits from the no-charge-to-the-government ECPs [Ref. 57].

D. DIFFICULTY IN PRICING THE RIW

The difficulty in projecting and predicting failure rates and the potential for reliability improvements makes it almost impossible to accurately cost out RIW provisions. The application of RIW to state-of-the-art technology has resulted in a high risk factor being utilized by most contractors. Improved testing under realistic operational conditions has produced more reliable failure data and reduced the wide confidence interval of achievable failure rates.

One RIW study [Ref. 58] determined that the incentive to improve testing in the developmental stage of an acquisition is positive when the contractor expects a procurement warranty to be applied. In order to adequately price out the RIW, the contractor must estimate the cost of a RIW from a projected reliability baseline. At best, the costing figure will be a gross estimate, but the range can be considerably narrowed if the contractor has a high degree of confidence in his projected failure rate based upon realistic operational testing. The researcher quoted an Air Force Logistics Command engineer as saying:

> I am somewhat surprised in discussions with members of industry, to find that the RIW is perceived more as a threat than a business opportunity. Typically, the major concern appears to be with the magnitude of risk that RIW poses to the firm and with means to pass that risk back to the government or to sub-tier vendors. This concern is reflected in the risk premiums contained in the warranty pricing. In some instances, the risk premiums have been so excessive as to negate any utility in choosing the RIW approach. [Ref. 58]

E. TIMING OF THE RIW CONTRACT

As in all programs, a competitive environment influences the actions of the individual contractors throughout the acquisition cycle. In a competitive market, efforts to perpetuate a product line or acquire a new technology may influence decisions during engineering development. Too often, RIW prices in the early stages of the acquisition cycle are priced so as to stay competitive, without a full appreciation of later development and production impacts. Under these circumstances, the relationship of equipment performance and contract design requirements, as well as the relationship of price to estimated costs, including the risk coverage, may be heavily biased in order to respond to the competition. As an example, the F-16 RIW was procured prior to full scale development, while competition still existed. Although the risks of such an early commitment were well recognized, the importance of obtaining RIW prices in a competitive environment were considered paramount. A number of actions were taken to keep risks under control, but these may not have prevented the ability of the contractor to recover any losses through modification of RIW contract requirements. A final study of the F-16 [Ref. 57] recommended that a RIW procurement should not be attempted prior to single-source contracting unless the product's design was reasonably stable, contractor risks were well defined and

controlled, and there was little likelihood of changing contract requirements.

F. RIW EXTENSIONS

Modifying a contract with a sole-source supplier may lead to difficulties. With the F-16 aircraft, there were circumstances involving the European partners that forced such a change. Specifically, because of the severely compressed initial procurement schedule and the uncertainty about European interest and involvement in the F-16 RIW program, the original RIW terms and conditions involved only U.S. Air Force aircraft. When it was decided that the European aircraft purchases would be fully merged within the U.S. Air Force RIW contract, the decision caused a renegotiation of the RIW. Such a renegotiation may cause the effectiveness of a RIW to be lost. The contractor's motivation during contract modification may not be as economical to the government as it was during initial contract negotiations. [Ref. 57]

A similar situation occurs when RIWs are considered for multi-service procurements: witness the NAVSTAR GPS (Global Positioning System). The program is headed by the Air Force, which regards the use of a RIW most favorably. The Navy, however, is undecided upon which maintenance concept to develop: organic or commercial. The Army is also involved in the GPS procurement. With such a wide range of applications and maintenance philosophies, it appears the use of fixed price RIW contracting may present too many difficulties to overcome in multi-service contracts.

The uncertainty of available funding for RIW extension upon the expiration of a contract has many maintenance managers worried. If the contractor substantially raises the price of commercial support during RIW extension

negotiations, the military may, for economic reasons, be faced with a very difficult decision. One recourse is organic support, which without a well planned and long lead-time transition would seriously degrade operational capabilities. Another choice is to establish alternate commercial repair capabilities; this would probably be acquired at a substantial premium also.

VII. ALTERNATIVES TO RIWS

Is there a better way to motivate contractors towards improving the reliability of their products? This chapter touches upon some alternate avenues of ensuring equipment reliability.

A. COMMERCIAL AIRLINE WARRANTIES

There might be a correlation between warranties and increased MTBF in commercial airline avionics, but causality has not been clearly established [Ref. 11].

Commercial avionics characteristics are determined by the Airline Electronic Engineering Committee. These characteristics are form, fit, and function type standards to which designers and suppliers provide equipment that is interchangeable between manufacturers. The benefit of interchangeability is that it enhances the competitive atmosphere, since a poorly performing item can be easily replaced by a competitor's item. [Ref. 59] Thus competition, not warranties, is probably responsible for high reliability in commercial avionics equipment [Ref. 54]. The same degree of competitive interchangeability does not exist in most military equipment acquisitions.

B. GRADUAL TRANSITION FROM RIW TO ORGANIC REPAIR

One alternative contracting technique is to make the first few years of a RIW program the same as they are now managed. Then, based upon returned failures at the end of this period, different modules and System Replaceable Assemblies (SRAs) would be stocked in the supply system for issue to the Intermediate Maintenance Activity (IMA).

The IMA would then fault diagnose WRA failures, replace the failed module or SRA, and return the failed SRAs to the contractor for RIW repair. Those WRAs that the IMA could not repair would also return to the contractor for RIW repair. Maintainability design and contract arrangements would protect the contractor from organic maintenance induced failures. This RIW method would allow the military to become involved in the maintenance, and influence repair activities, much earlier than normally experienced with RIWs. [Ref. 60] It would also allow stockage of smaller sub-assemblies at a much lower total inventory cost than stocking only complete WRAs for spares. This proposal provides for emergency cannibalization when the supply lines become disrupted, yet continues returning unserviceable components to the contractor so that he may conduct engineering studies and propose ECPs. [Ref. 54]

C. FIXED PRICE INCENTIVE CONTRACTS

The Firm Fixed Price (FFP) contract does not allow the government to get the actual contract cost information from the contractor at the end of the contract. A Fixed Price Incentive (FPI) contract does. With actual cost information, the government is in a better position to judge its costs for organic maintenance, and has better data with which to negotiate new RIW contracts. The U.S. Army used this concept with the Blackhawk helicopter RIW. It was negotiated as a one year contract with three separate one year extension options. The Army thus was not locked into contractor support for longer than one year. [Ref. 54]

The particular Army command awarding the RIW felt that FPI contracts were cheaper to the government, in the long run, than FFP contracts.

For developmental items, the FPI contract seems to be the best contract. It recognizes the contractor's risks and provides the government with actual cost data. However, reducing the contractor's risk through a FPI contract may reduce the contractor's motivation. [Ref. 54]

D. RECENT ENGINE WARRANTIES

In the mid-1970s a Navy study reported:

> In many airline warranties, provision is made for airline maintenance on warranted units. The vendor than reimburses the airline for maintenance cost. Most contractors have expressed reluctance to enter into such an arrangement with the military, because they feel that the high turnover rate in maintenance personnel would adversely affect repair procedures. [Ref. 31]

Air Force engine contracts have recently used both this method and an opposing one for performing repairs. "With the F100, plans call for Pratt & Whitney to do the work, while General Electric will reimburse the Air Force for work done at service depots." [Ref. 13] General Electric was to grant 100 percent allowance for materials and depot labor for TF34 engines. One factor that required negotiation in the other contract was how to cope with the lingering effects of the early 1979 strikes at two Pratt & Whitney subcontractors. Despite this problem and the historic desire of the military services to perform their own maintenance, the Air Force Aeronautical Systems Division cited one major advantage inherent in the Pratt & Whitney contract. The existence of a sizable maintenance demand on the F100 would provide a commercial overflow, or surge capability if needed. [Ref. 13]

General Electric's F404 engine warranty proposal to the Royal Australian Air Force (RAAF) was presented as two options. Each option covered parts and labor for any

primary and secondary damage to the full engine. The proposal stated:

1. The engine and all components would be warranted for 750 hours or 2000 Tactical Air Command Cycles, whichever came first.

2. Australia would be guaranteed that maintenance costs over the same usage period would not exceed a cost based on General Electric's reliability projections. If the costs did exceed that figure, General Electric would pay the difference up to a limit, or cap.

The cap was a type of contractor liability limit, which was set well above the contractor's price for the warranty. Although the warranty was with the RAAF, they planned to subcontract the engine maintenance work to an Australian contractor. General Electric's intention was that RAAF personnel or Australian industry do the maintenance and be reimbursed or, under the second option, be credited toward the cap. [Ref. 14]

E. USING THE PRESENT SYSTEM

Several short term RIWs have shown large MTBF improvements with no ECPs. The improvements were incorporated during design and production by placing a greater emphasis on reliability and strictly enforcing reliability design specifications. Are RIW type special programs necessary for good reliability? Perhaps better design specifications and improved enforcement of standards could do the same job more easily and at lower cost. [Ref. 61]

The Navy's organic repair facilities and IMA/Depot infrastructure could more aggressively pursue equipment reliability improvements, perhaps making RIW type programs obsolete. Instead of a particular equipment problem going on for years without an engineering change, the organic maintenance system could become more sensitive and responsive to reliability improvement needs.

VIII. CONCLUSIONS AND RECOMMENDATIONS

Considerable experience and data have been gained since the introduction of the FPW/RIW as an acquisition concept. Much of the significant data originating from RIWs, used in the acquisition of both major and smaller systems, have shown the RIW to be a cost effective way to improve equipment reliability. However, the data and experiences also revealed that the impact of using RIWs has been far greater than originally anticipated.

RIW use inherently implies that a tremendous amount of research and coordination has been done on the part of the contractor and the military. The contractor must understand what the military wants, and be able to confidently assess the risks involved, to respond with RIW proposals. The military must first define what it wants the RIW to achieve: higher reliability and/or lower life cycle costs. Once this is done, the impacts on the overall maintenance concept, manpower, data systems, and administration of the contract must be determined. Unfortunately, this is the area where major implementation difficulties have been experienced.

The special attention, documentation and individual management of RIW equipments, throughout the entire fleet logistic chain, has never been given consideration in formal RIW contract proposals and evaluations. The additional personnel requirements have not been addressed in a cost/benefit analysis of RIWs. In addition, the cost of lost opportunity from assets sitting on shelves instead of operating, has never been calculated, and methods for ensuring maxium operational employment of RIW equipments have not been seriously explored.

The use of a RIW requires the collection of extensive data by both the contractor and the Navy to effectively manage and evaluate the contract. The data requirements become even more complex because each RIW program is unique. Component serial number control, operational hours, removal and installation dates, and failure cause data, must all be gathered and analyzed in order to measure the performance of warranty commitments. We have become conditioned to paying the contractor for data, but a growing number of fleet personnel are concerned enough about relieving the technician's burdens, that reducing data collection requirements is now a major movement. RIWs and their requirements have added to the maintenance data collection problems already faced by maintenance managers.

Discussions and interviews with Navy personnel involved in all levels of maintenance management revealed that individuals must be made aware of what a RIW is, what part they play in it, and how their actions or decisions impact on others involved in the program. For the RIW to be effective, there must be greater effort to educate those involved with RIWs, not only at the policy levels, but at the working levels, also. Without education, RIWs will continue to be a stumbling block and disruptive program, making aviation maintenance more difficult than ever.

Naval logistic channels often not only become long, but very thin. Whereas shore activities can be resupplied by air, ground, and often sea, the deployed aircraft carrier does not have a highly flexible and dependable ground support option. Problems multiply as the ship extends further from the nearest land base. Ship replenishment routes are long and typically slow, while the air supply line becomes less dependable. Island hopping resupply routes, such as used in the Indian Ocean, stretch the logistics system to its limit. As a result, higher priority for shipping and handling of RIW assets is required.

A RIW automatically establishes the logistic support method during the warranty period. Most RIW applications are for a two to five year obligation, with a transition to organic maintenance capability at the termination of the contract. This concept requires early planning and coordination to insure that the manpower, support equipment, spares, training, and technical publications are available. As more and more of the impacts are addressed, additional questions arise; the answers indicate that RIWs are not as easy to apply and administer as originally thought. The effects of using a RIW have shown that interested players should be more involved in the conceptual stage of the acquistion process to assure a smooth, cost effective, and reliable introduction into the fleet. The pursuit of a truly Integrated Logistic Support (ILS) approach is one such management technique. ILS provides the initial planning, funding, and controls which will help to assure the fleet receives not only reliable equipment, but components that can be expeditiously and economically supported throughout the programmed life cycle.

The principle objective of a RIW is to improve reliability. Reliability testing is conducted to provide an evaluation of system development progress, as well as the assurance that specified requirements have been met. Operational performance, maintainability, and supportability characteristics are measured and evaluated during system test and evaluation. By closely monitoring these characteristics during the various stages of system evaluation, improvements in testing can be made. Reliability parameters should be specified more in terms of operational usage and demonstration, with the appropriate conditions identified and simulated as closely as possible. Many times, the reliability required by fleet aircraft and that demonstrated in the contractor's laboratory are not synonymous.

More emphasis should be placed on building reliability and maintainability into a system, rather than providing for improving these characteristics after the system is in service.

There is a need for the formation of an adequate data base from which to make intelligent decisions concerning non-RIW versus RIW support for particular equipments. The success of this effort will depend on how well the previously cited difficulties of quality data collection can be overcome. The accumulation of an accurate data base will allow for the constant monitoring of RIW contracts. Evaluating the experience of ongoing warranty programs is the best basis for developing improved terms, conditions, and decision processes for future RIW procurements. The service's efforts, pursued by the Air Force's Product Performance Agreement Center and the Navy's Aviation Supply Office Technical Division, should be staffed and provided the resources required to evaluate the overall program results. This more centralized management of RIW evaluation should be undertaken to enhance and improve the understanding and application of the data obtained. Such an improvement is necessary to properly develop and implement future Reliability Improvement Warranties.

LIST OF REFERENCES

1. Carlucci, F. C., Improving the Acquisition Process, memorandum for the Secretaries of the military and other departments, 30 April 1981.

2. Solomond, J. P., "Contractor Incentives to Improve Reliability and Support", The Journal of Defense Systems Acquisition Management, p. 137, Summer 1982.

3. Naval Material Command, Washington, D.C., Navy Program Manager's Guide, December 1980.

4. The Journal of Defense Systems Acquistion Management, Summer 1982.

5. Balaban H., and Retterer, B., An Investigation of Contractor Risk Associated With Reliability Improvement Warranty, ARINC Research Corporation, April 1977.

6. U.S. Naval Aviation Supply Office, Proceedings of Failure Free Warranty Seminar, 12-13 December, 1973.

7. Logistics Management Institute, Washington, D.C., Life Cycle Costing in Equipment Procurement, p. 6, April 1965.

8. Markowitz, O., "Introduction to Failure Free Warranty", Journal of the Society of Logistics Engineers, Logistics Spectrum, p. 26, Winter, 1975.

9. Director, Defense Research and Engineering, RIW Guidelines, 13 August 1974.

10. Hunt, D. E., A Model for Contracting Pricing for Use by Government Depots in Conjunction with the Use of Government Depot Warranties in Multi-Year Contracting at Fixed Prices, Aerospace Guidance and Metrology Center, Newark, Ohio, p. 3, 1974.

11. Dagen, H., and others, Investigation of Reliability and Analysis of IOT & E Test Data for AFSATCOM, ARINC Research Corporation, 1975.

12. Field Aviation Supply Office Instruction 4440.86C, FFW/(Failure Free Warranty)/RIW(Reliability Improvement Warranty): Program for, 01 February, 1977.

13. "GE to Expand Warranty Offer to Navy", Aviation Week and Space Technology, 27 July, 1981.

14. "TF-34 Warranty Pact Reached", Aviation Week and Space Technology, 13 January, 1981.

15. Markowitz, O., "ASO History and Application of RIW", Navy Supply Corps Newsletter, December, 1977.

16. Aviation Supply Office, Technical Division, Case History, AJB-3 Gyro, April, 1974.

17. Aviation Supply Office, Technical Division, F-18 RIW Candidate Selection Process, 1978.

18. Aviation Supply Office, Technical Division, Case History--ABEX Hydraulic Pump, 10 February, 1978.

19. Aviation Supply Office, Mid-Contract Report--ABEX Pump, 15 October, 1977.

20. Naval Air Rework Facility, Avionics and Components Engineering Division, NAS North Island, San Diego, California, RT-868A/APX-76 and RT-988/A Relibility Improvement Warranty Program, 1975.

21. Naval Air Rework Facility, North Island, California, Avionics System Life Cycle Support Plan RT743B/ARC-51 April 1982.

22. Naval Air Systems Command, F-18 RIW Planning Preliminaries, memorandum from AIR-02A to PMA-265, 30 March, 1976.

23. ARINC Research Corporation, Determination of Expected Maintenance--Cost and Readiness Drivers and Controls for the CH-53E Helicopter, Report No. 1182-01-1-1548, October, 1976.

24. Kiefer, R. W., LT, USN, SC, RIW for F-404 Engine Accessories, Aviation Supply Office, memorandum from WLW9-A to SCW2-A, 22 November, 1978.

25. Bradney, J. M., CAPT, USAF, and Perkins, M. M., CAPT, USAF, Proposed Criteria for Evaluation of the Reliability Improvement Warranty Concept, Air Force Institute of Technology, Wright-Patterson Air Force Base, Ohio, Master's Thesis, June, 1980.

26. Jacobson, M. C., CAPT, USAF, and Skaggs, R. L., CAPT, USAF., Evaluation of and Recommended Change to the Reliability Improvement Warranty (RIW) Guidelines, Air Force Institute of Technology, Master's Thesis, 11 September, 1979.

27. Bureau of National Affairs, Inc., Washington, D.C., No. 883, page A-1, 25 May, 1981.

28. Markowitz, O., Problem Definition and Statement Applicable to Failure Free Warranty Technique in Contracting, Aviation Supply Office, Technical Division, memorandum, 19 January, 1973.

29. Atkins, W.A., Failure Free Warranties, Aviation Supply Office, Technical Division, memorandum to Commanding Officer--ASO, 5 October, 1973.

30. DoD memorandum, Trial Use of RIW in the Acquisition Process of Electronic Systems/Equipment, 14 August, 1974.

31. Bizup, J. A., and Moore, R. R., Techniques For Selecting and Analyzing Reliability Improvement Warranties, Naval Weapons Engineering Support Activity, Weapon Systems Analysis Department (ESA-19), Washington Navy Yard, R-7505, June, 1975, revised June, 1976.

32. Chief of Navy Material, Trial Use of RIW, 13 June, 1975.

33. Aviation Supply Office, Technical Division, FFW Plan No. 001, 16 March, 1976.

34. Bruns, M. D., RIW Funding Policy, Office of the Assistant Secretary of Defense, OASD (I&L)WS, memorandum to Mr. O. Markowitz, 12 March, 1976.

35. "Warranties: Air Force Plans Extended Use of Innovative Warranties to Emphasize Product Performance, Reliability", Federal Contract Reports, No. 883, A-1, 25 May, 1981.

36. Brown, T., Air Force Logistics Command, telephone interview, 23 July, 1982.

37. Coxon, W., Reliability and Maintainability Integrated Logistics Support, ASW Test Directorate, Naval Air Test Center, personal interview, 21 September, 1982.

38. Stark, F. T., "Effects of Reliability Improvement Warranty (RIW) on Program Profit", *Proceedings of the Eleventh Annual International Symposium*, McDonnell Aircraft Co., August, 1976.

39. Balaban, H. and Retterer, R., *Guidelines for Application of Warranties to Air Force Electronic Systems*, ARINC Research Corporation, December, 1975.

40. Cozzolino, J. M., and Moore, W. F., "More Effective Cost-Incentive Contracts Through Risk Reduction", *Defense Management Journal*, July, 1978.

41. Dugan, W. C., Manager of Navigation Contracts, Magnavox Advanced Products and Systems Company, Torrance, California, personal interview, 9 August, 1982.

42. Army Procurement Research Office, *Contractor Motivation Theory and Applications*, report number APRO 80-06, March, 1981.

43. Murillo, T., Avionics Division, Naval Air Rework Facility, North Island, personal interview, 10 August, 1982.

44. Sweney, R. L., LT, USN, SC, *An Independent Look at the Controversy of Reliability Improvement Warranties*, Master's Thesis, Naval Postgraduate School, Monterey, California, 1979.

45. "Reliability by Design, Not by Chance", *Defense Management Journal*, April, 1975.

46. Rohal, P., Force Material Division, Commander Naval Aviation Pacific, personal interview, 11 August, 1982.

47. Cope, J., LT, USN, Avionics Division Officer, Aircraft Intermediate Maintenance Department, Naval Air Station, Brunswick, Maine, telephone interview, 9 August, 1982.

48. ARINC Research Corporation, *F-16 RIW Implimentation and Management Plan*, April, 1979.

49. Seeley, CAPT, USN, Reliability, Maintainability, and Quality Assurance, Naval Material Command, personal interview, 24 September, 1982.

50. Sharp, G. W., Capt., USAF, and Toshach, J. C., *An Analysis of USAF Depot Level Maintenance Capability to Meet Surge Requirements for a RIW Item: The C/KC-135, C-141 Inertial Navigation System*, Master's Thesis, Air Force Institute of Technology, Wright-Patterson AFB, Ohio, 1976.

51. Deputy Secretary of Defense memorandum, Industrial Preparedness Policy Statement, 6 March, 1982.

52. Cox, L., Reliability Improvement Warranty Terms and Conditions for the Integrated Avionics Control Systems (ICAS), ARINC Research Corporation, May, 1979.

53. Hengstebeck, R. A., Technical Division, Aviation Supply Office, personal interview, 20 September, 1982.

54. Tucker, M. P., CAPT, USA, In Defense of the RIW, Florida Institute of Technology, Fort Lee, Virginia, 2 June, 1980.

55. Air Force Audit Agency, Impact of New Management Concepts on Support and Maintainability of Avionic Equipment, 23 March, 1979.

56. Henry, C., Naval Air Systems Command, AIR-4105, Head--Program Support Branch, personal interview, 24 September, 1982.

57. Harrison, G. T., and Balaban, H. S., Final Summary Report, F-16 RIW Project, ARINC Research Corporation, 2 March, 1979.

58. Shmoldas, J. D., Major, USAF, Improvement of Weapon System Reliability through Reliability Improvement Warranties, Defense Systems Management College, Fort Belvoir, Virginia, May 1977.

59. Schmidt, A. E., A View of the Evolution of the Reliability Improvement Warranty, Defense Systems Management College, Fort Belvoir, Virginia, 1977.

60. Russell, T. B., "Is the Army Satisfied with Reliability Improvement Warranties?", Paper presented to the Thirteenth Joint Services Data Exchange for Inertial Systems, St. Louis, Missouri, 14-16 November, 1979.

61. Habicht, R. F. Reliability Improvement Warranties: Government Benefits, Contractor Risks, Master's Thesis, Naval Postgraduate School, Monterey, California, 1976.

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